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Hydrocarbon Sensor for Exhaust Gas Monitoring

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Due to increasing environmental concerns, in 1994, the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA) began implementing regulations that require automakers to incorporate comprehensive on-board diagnostics into new vehicles. The purpose is to monitor emissions, which will allow early detection of any malfunctioning of the engine and/or exhaust treatment system. Currently, monitorings of hydrocarbon and NOx emissions are regarded as being the most critical for evaluating car emissions.

We have developed at Lawrence Livermore National Laboratory a novel sensing approach for hydrocarbon detection (1). The novel sensor uses a high temperature proton conducting electrolyte and a dehydrogenation catalyst. Structurally, the sensor consists of the proton conductor sandwiched between two platinum electrodes. This arrangement is in essence a hydrogen sensor. When a dehydrogenation catalyst (iron oxide) is deposited on top of one of the electrodes, dehydrogenation of the hydrocarbons generates extra hydrogen on the catalyst side of the sensor. The measurement of the emf developed across the sensor is a measure of the amount of hydrocarbons present in the exhaust. This sensing mechanism does not require a reference gas. The sensor has interesting characteristics such as very high selectivity, no sensitivity to gas flow and weak temperature dependence. However, the major drawback was a large effect of oxygen concentration on sensor signal. This effect was attributed to the highly active Pt electrode, which catalyzes the oxidation of hydrogen when oxygen is present.

We have developed a second generation of this sensor. The Pt electrode is completely removed on the catalyst side. Since the iron oxide is a semiconductor with reasonable electronic conduction at high temperature, and since the sensor just requires the measurement of the voltage, the iron oxide can perform simultaneously as a dehydrogenation catalyst as well as the electrode for the proton conducting electrolyte.

The new sensor has been characterized in a variety of gases, including oxygen, ethane, propylene, carbon monoxide, hydrogen and water in nitrogen. The sensor shows similar characteristics as the previous generation. However, the dependence on oxygen concentration in exhaust gas is significantly reduced. Due to reduce sensitivity to oxygen content, the new sensor can be used in both lean-burn and fuel-rich conditions.

References

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